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Rings

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ON THE

GROWTH OF CERTAIN CALIFORNIA FOREST TREES AND THE METEOROLOGICAL INFERENCES SUGGESTED THEREBY.

BY ROBT. E. C. STEARNS, PH. D.

WHILE in Napa county, during the month of October, 1881, I noticed in a clearing lately made on the top of Howell Mountain that, in felling, most of the large trees had been sawed across at the butt, instead of being chopped down with an axe, thus making an even cross-section or plane surface, and admitting of the counting of the rings of growth.

It was my intention at the time to have taken these notes myself, and, further, to have made a diagram showing the exact width or thickness of each of the annual rings, in order to make a comparison of one tree with another and to learn whether the annual rings or growths of ea year, commencing with the last year and comparing ba ward, year with year and tree with tree, exhibited a co cidence in thickness or a coincidence in variation. Bef proceeding further in the elaboration of this point I w state that lack of time prevented my making the diagra and that the following measurements of four trees of the species known as *Pinus ponderosa*—or yellow pine—were made for me by Mr. A. L. Roache, who was then visiting the region:

	Inside of bark. Inches.	Outside of bark. Inches.	Annual Rings.	Average Annual G inside of bark—in
No. 1.	20½	24½	54	.3796
No, 2...	27½	30½	75	.3666
No. 3.... ...	33½	38	80	.4187
No. 4.	24	29½	72	.3333

Mean annual growth, .3745 of an inch.

The thickness of the bark, it will be seen, varies co erably. The differences in the diameters, as shown in columns, "inside" and "outside of bark" being tha the bark on the two sides of the tree, require therefor be divided by two, to give the true thickness, and g No. 1, two inches; No. 2, one and a half inches; N two and a quarter inches; and No. 4, two and three-q ter inches.

These trees stood in such a station or position, as to formity of conditions, *i. e.*, character of soil and sur exposure, etc., as to furnish a fair basis for a calculati the kind herein made.

It will be observed, upon adding up the column of an rings, and also the column of largest diameters, and dividing these totals by four to get the average, that in region where they grew, about seventy years were requ to make a yellow pine thirty inches, or two and a half in diameter. The mean thickness of the annual ring the above trees, .3745 of an inch, is nearly three-eighths of an inch, or .3750.

If we had similar and sufficient data from various places, we might make a pretty accurate approximation and generalization of the kind above illustrated; in this, the data being limited, the region to which they apply must also be limited, and to the species—the single species only—as above given.

The pines are quick-growing trees, and, in common with other related forest forms, make a proportionately larger growth in their early years, or, in other words, make thicker annual rings when young than when old, though in an equally vigorous condition, so that a measurement of young trees, though useful as showing how long we may have to wait to get a profitable return in fuel or lumber from an artificial plantation; such young trees would not answer the purpose of a standard of age or measurement for the large trees of natural forests.

In the neighborhood of Berkeley, trees of the Monterey pine, nine to ten years of age, show a maximum diameter of one foot three inches, being a growth of over an inch a year, and a mean diameter, so far as I have measured, of nine inches, the result of several trees. These were planted for ornamental purposes.

Sections of the following species of forest trees, indigenous to the Pacific Coast, are contained in the Museum of the University of California, and yield the data given below:

Abies grandis, or white fir—Larger diameter, 23 5-16 inches; smaller diameter, 22 11-16 inches; mean diameter, 23 inches; thickness of bark, three-fourths of an inch; annual rings, 146; mean annual growth, .1575 of an inch, or a little under one-sixth of an inch per annum.

Abies Douglassii, or Tsuga Douglassii, the hemlock spruce, so called—Larger diameter, 17⅞ inches; smaller diameter, 16⅝ inches; mean diameter, 17¼ inches; thickness of bark, half an inch; annual rings, 96; mean annual growth, a trifle under .18, or something over one-sixth of an inch.

Abies Mertensiana—Larger diameter, 18¼ inches; smaller diameter, 16¾ inches; mean diameter, 17½ inches; thickness of bark, a trifle over half an inch; annual rings, 110; mean annual growth, nearly .160, being something less than one-sixth of an inch per annum.

These three species of *Abies* are represented in the above measurement by trees which grew in or near Gualala, Mendocino county, an exceptionably favorable station so far as moisture is concerned, the country being well watered, and the county, in common with the entire region from the Oregon line to and inclusive of Marin county as the southern terminus, being part of a meteorological province, which receives not only a greater average rainfall than other parts of the State, but also the fullest advantage of the summer fogs which, borne shoreward by the trade-winds, are condensed by the lofty evergreens which here abound and fall to the ground, dripping through the foliage of the trees, like a gentle shower. A comparison of so moist a region with the drier areas, shows at a glance the necessity of a careful consideration of environmental conditions in connection with deductions from data, of the kind herein referred to.

A section of *Sequoia sempervirens*, our common redwood, shows, counting from the circumference toward the center, a growth of three inches in 95 years, or, more particularly, 95 growth rings averaging .0316 of an inch per annum. Notwithstanding the majestic proportions which the *Sequoias* attain, the above measurement, as well as an examination of the ends of a large number of redwood boards, show that these trees are of slow growth.

The measurements of a specimen of *Sequoia gigantea*, as given with great particularity by Professor Whitney in the

Yosemite Guide Book (edition of 1870), pages 147–8, give a mean diameter of 23 feet $3\frac{3}{4}$ inches, without bark, and 1,255 annual rings, a mean annual growth of only .2229 of an inch, very nearly, being less than one-quarter of an inch a year.

It is not unlikely that the comment may be made, that the data here presented are so meager as to be of little value, though perhaps interesting and suggestive. This I am quite ready to admit, and while doing so will revert to the point temporarily dropped near the beginning of this paper, and speculate a few moments in the direction which said point indicated.

METEOROLOGICAL INFERENCES.

Any one who has taken the trouble to examine the annual growths, or width of the annual rings in trees, has at once perceived a great difference in their thickness in the same tree. If we may assume (leaving out young trees) that this variation is principally due to the amount or quantity of the rainfall, and that rings which exhibit maximum thickness have followed in their growth seasons of maximum rainfall, and the thinner rings are consequently the result of the influence of seasons of a less or minimum rainfall, we may also assume that if, upon a given date, numerous trees were felled so that we could have transverse sections of all of the principal species, such trees being located at various points in the State, great care being taken that the trees so selected should have been subject, as nearly as possible, to the same environmental conditions, we might obtain an aggregation of data of sufficient volume to render a deduction therefrom of great value, as to the meteorology of the Pacific Coast. We might find so close a parallelism between rings of maximum thickness and seasons of maximum rainfall, that we should be justified in regarding this parallelism as something more than a series of coincidences merely, by finding these coincidences so persistent as to prove a correlation; and we could, perhaps, base our weather prognostications upon something more than a guess, and learn whether or not there is a periodicity or cyclical terms of wet and dry years. having the data before us according to the trees selected and examined—reaching back with the Pines from seventy-five to one hundred and fifty years, with the Redwoods from five to seven hundred or more years, and with the *Sequoias* of the Sierra from twelve to fourteen centuries, to say nothing of the testimony of other trees, the Madronas and Oaks especially.

The forest monarchs of the Sierra Nevada and the Coast ranges offer a calendar whose records have been written by the elements; and so far as the giant *Sequoias* are considered, their evidence would certainly be that of the oldest inhabitants, substantially supported by their first of kin, the magnificent redwoods of the Coast ranges.

Another matter of minor, though not of insignificant importance, would be the relation between greatest diameter and the points of the compass, as to whether the greatest diameter is persistently incidental to a certain aspect or quarter of the compass. In the specimen of *Sequoia gigantea* above mentioned, Professor Whitney gives the greatest diameter, *north and south*, as twenty-four feet and one and one-half inches: while the "shorter diameter, or that east and west, was 23 [twenty-three] feet, divided exactly even on each side of the center." "Across its longest diameter, south of center, 13 feet 9½ inches." "Across its longest diameter, north of center, 10 feet 4 inches," or twenty-four feet and one and one-half inches, as before stated, a difference between the north and the south side of the center, of *three feet and five and one-half inches in favor of the latter*.

Difference in the diameters may be traced perhaps to a difference in the amount of heat and light, which one side of tree receives as compared with the other; to the influence of prevailing winds according to the station, position or exposure; or to local or general magnetic influences—local as peculiar to small areas, or general as pertaining to larger or extensive regions. An accumulation of data might show a marked and constant character in the relation of diameters to such factors of the environment; and also a marked character in the diameters of one region, as a whole, when compared with another region, where modified or different climatic conditions exist.

In a comparatively arid region, with a high mean temperature and infrequent rainfall and a dry atmosphere, we may suppose that the southerly half of a tree, following the curve of its circumference *from east by way of south to west*, might, through excess of light and heat, suffer from dessicating influences, and make a less growth than the northerly half, following the curve of the trunk *from east by way of north to west*, as the northerly half would have the advantage, if advantage it be, in such a climate, of less light and heat and more shade; while in a region less arid with a much lower mean temperature, etc., the greater proportion of light and heat which the southerly half receives, would give that side of the tree an advantage over the northerly half.

As to the effect of prevailing winds in differentiating the diameter, we may suppose that the side of a tree most exposed might be affected, and the growth on the windward side much modified or repressed; while the leeward or sheltered side, being protected, would exhibit a greater diameter or semi-diameter, measuring from the true center of the tree, *i. e.*, from its initial ring.

In the "big tree" measured by Professor Whitney, the southerly half of the diameter shows the excess, indicating that heat and light were specially advantageous; but here altitude comes in as a factor, as the height of the Calaveras grove, or rather its site, is 4,759 feet above the level of the sea, an elevation where, though the heat of the six mid-day hours in June and July is 80° and upwards, the nights are cool; and as Professor Whitney remarks, "during ordinary years, . . . the flanks of the Sierra are well covered [with snow] down to 4,000 feet above the sea during mid-winter months, and a heavy body of snow lies on the passes until May, or even June." So after the snow has melted up to and above the altitude or site of the grove, the atmosphere is cooled for a long period afterwards by the snow-clad slopes and the unmelted masses of snow upon the higher flanks of the Sierra beyond.

In the consideration of all the factors which suggest themselves, and which no doubt are more or less operative or interoperative, the least perceptible, though perhaps the most important, is that of compensation, which modifies or neutralizes what at first appear to be conspicuous and dominating influences.

What is above presented, it should be understood, is simply hypothetical, and for the purpose of awakening discussion and calling attention to a most interesting subject; one which, if generally understood, would be of great practical importance. At present the data are so exceedingly meager as to preclude anything more than speculation, or to incite to and stimulate investigation.

From a knowledge of the various points of inquiry herein suggested, might be deduced a generalization, indicating a universal and preponderating law.

Berkeley, California, Feb. 10, 1882.

[Note. Portions of the foregoing were read before the California Academy of Sciences, December 5, 1881. It has since been revised and materially modified and expanded.]

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